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**What do you see?**

Hydrogen fuel cells are based on the principle of galvanic cells, in which the chemical reactants are oxygen and hydrogen gases that flow past the anode and cathode. The chemical reactants are continuously supplied and consumed to produce water and electricity.

1. Write the equation for the overall cell reaction that occurs in a hydrogen fuel cell?
2. Write down the half-reactions which occur at the cathode and anode in a hydrogen fuel cell?
3. Calculate Eocell for a hydrogen fuel cell.
4. How do hydrogen fuel cells offer an environmentally friendly alternative to usual car batteries?
5. What is the source of oxygen and hydrogen for these fuel cells?

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**What does it make you wonder?**



**What do you see?**

Electroplating is a process in which a metal is deposited on the surface of an object, placed at the cathode of an electrolytic cell.

1. Suppose you want to set up an electrolytic cell to electroplate some metal spoons with a thin layer of silver.

a) As part of the experimental design, draw the cell and label the electrodes, power supply, electrolyte, and the direction of electron and ion movement.

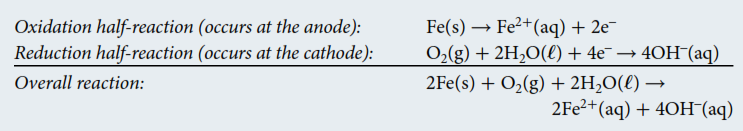
b) What variables must be considered when planning the electrolysis?

1. List some reasons for, and examples of, electroplating.
2. Electroplating solutions become dirty after few uses and need to be replaced. These electroplating solutions that can no longer be used are called as ‘spent’ electroplating solutions. How should the electroplating waste be managed?

**What does it make you wonder?**

  
   
**What do you see?**

Rust is a hydrated iron (III) oxide, Fe2O3.xH2O. The rusting of iron involves the reaction of iron, oxygen, and water in a naturally occurring galvanic cell on the exposed surface of the metal. There are usually many of these small cells on the surface of the same piece of iron. In each small cell, iron acts as the anode. The cathode is inert and may be an impurity that exists in the iron or is deposited onto it.



1. Determine the standard cell potential for the corrosion reaction.
2. What is the electrolyte for the corrosion reaction?
3. Does the acid rain prevent or promote the rusting of iron? Why?
4. What are some societal consequences of corrosion?

**What does it make you wonder?**





**What do you see?**

Corrosion could be prevented by galvanization and cathodic protection. Galvanizing is a process in which iron is covered with a protective layer of zinc. When this protective layer is broken, zinc acts as a sacrificial anode because it is destroyed to protect the iron. Cathodic protection is another method of preventing rusting in which a more reactive metal is attached to an iron object. The reactive metal acts as a sacrificial anode, and the iron becomes the cathode of a galvanic cell. As the sacrificial anode is slowly destroyed by oxidation, it must be replaced periodically.

1. Explain why a protective layer of zinc on iron can provide protection against corrosion?
2. Does a protective layer of tin on iron provide effective protection against rusting?
3. Explain why aluminum provides cathodic protection to an iron object?
4. A zinc wire is connected to and buried with a pipeline when it is built. Why is this done? What are some of the environmental and safety issues associated with protecting and also not protecting pipelines.

**What does it make you wonder?**





**What do you see?**

Primary batteries stop producing electrical energy once the chemical reactants in them are used up. On the other hand, secondary batteries can be recharged when electrical energy is provided to them. By driving the chemical reactions in a battery backward, the original chemical reactants can be regenerated. Rechargeable lead-acid batteries are used in cars. Rechargeable nickel-cadmium (NiCad) batteries are used in portable devices, such as laptops, digital cameras, video games, etc.

1. Do rechargeable batteries act as galvanic cell or electrolytic cell?
2. The overall reaction for a lead-acid battery is

Pb(s) + PbO2(s) + 4H+(aq) + SO4-2(aq) 🡪 2PbSO4(aq) + 2H2O(l)

a) Which material acts as the anode and which acts as the cathode in the reaction?

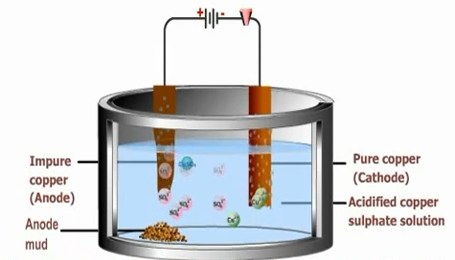
b) Write down the balanced half-reactions.

c) Write the two half reactions and the overall cell reaction for the process when this battery is recharged.

d) What external voltage is required to recharge a lead-acid car battery?

3) After being discharged completely, even rechargeable batteries wear out. What are some of the environmental hazards and health risks caused by the improper use and disposal of lead-acid and NiCad batteries?   
**What does it make you wonder?**

[](http://www.google.ca/imgres?q=electrorefining+of+copper&hl=en&sa=X&rls=com.microsoft:en-us&biw=1440&bih=741&tbm=isch&prmd=imvns&tbnid=nHHY1bhfskdPvM:&imgrefurl=http://www.im-mining.com/2011/07/13/fast-copper-electro-mining-process-patented-in-china/&docid=LiYigqu8WKb-vM&imgurl=http://www.im-mining.com/wp-content/uploads/2011/07/copper_1.jpg&w=500&h=437&ei=mp0ZT7mqJZKy0AHOr-zECw&zoom=1)



**What do you see?**

In industry, the process of purifying a material is known as electrorefining. After the extraction stage, some metals are refined in electrolytic cells. For example, copper is about 99 percent pure after extraction. The presence of impurities in copper lowers its electrical conductivity. The process of electrorefining uses an electrolytic cell to obtain high-grade copper at the cathode from an impure copper at the anode. During electrolysis, the impure copper anode dissolves, and pure copper is plated onto the cathode. The resulting cathode is 99.99 percent pure metal. Most impurities that were present in the anode either remain in solution or fall to the bottom of the cell as sludge called anode mud.

1) Write down the balanced half reactions which occur at cathode and anode.

2) Why must the pure copper metal product form at the cathode?

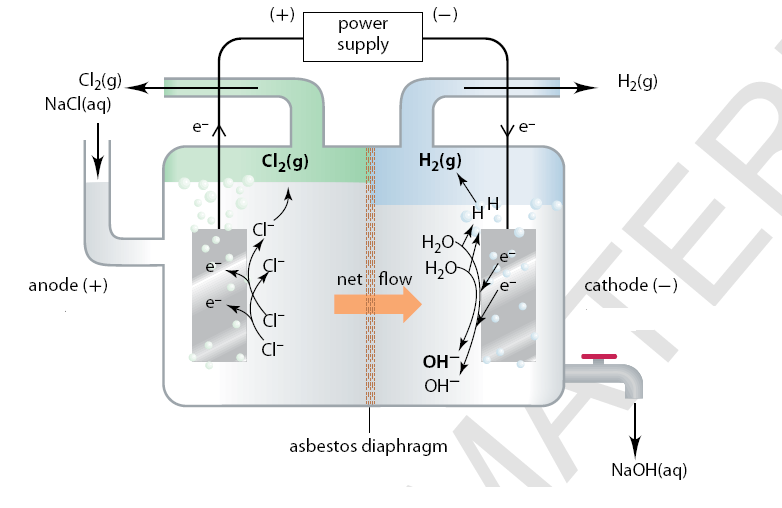
3) What is the minimum electric potential difference required for this cell?

4) Why is it unlikely that your answer to 2) is what is used? Discuss briefly.

5) How do you think the anode mud formed in this process is treated?

**What do you want to know?**

**What does it make you wonder?**



**What do you see?**

This figure shows the chlor-alkali process occurring in an electrolytic cell. The complete balanced equation for the redox reaction is

2NaCl(aq) + 2H2O(l) 🡪 Cl2(g)+H2(g) +2NaOH(aq)

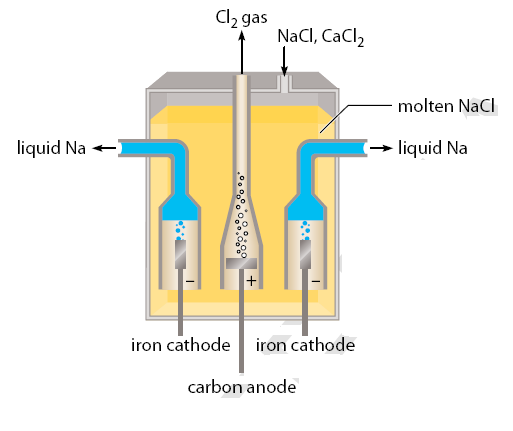
1)Why is the Chlor-alkali process commercially significant? What is the significance of the products produced in this process?

2) Write down the balanced half reactions at the cathode and anode.

3) What is the minimum electric potential difference required for this cell?

4) Chlorine is a controversial chemical. Although, chlorine and products made from chlorine have been very beneficial to society, there are some concerns. What are some the concerns that people have with the use of chlorine?

**What does it make you wonder?**

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**What do you see?**

Most elements occur naturally combined with other elements in compounds. Many metals can be extracted through the electrolysis of their molten ionic compounds. For instance, as sodium cannot be extracted by electrolysis in an aqueous solution, it is obtained through the electrolysis of molten sodium chloride in industry in a large cell known as Downs cell. The melting point of sodium chloride is about 800oC. Therefore, the Downs cell needs to be heated to such a high temperature for the electrolysis. To decrease heating costs, calcium chloride is added to lower the melting point of sodium chloride from about 800oC to 600oC.

1) Explain why sodium cannot be produced by electrolysis of sodium chloride solution in water.

2) Write the half reactions that occur at the cathode and anode in a Downs cell.

3) Write the net ionic equation for the overall cell reaction.

5) How can the industrial chemists ensure that only sodium ions (and no calcium ions) are reduced in the Downs cell?

6) Provided that the melting point of sodium is only 98oC, is the sodium obtained through this cell solid or liquid?

**What does it make you wonder?**